Module 6 Overview

Introduction

> *"Imagination is the Discovering Faculty, pre-eminently. It is that which penetrates into the unseen worlds around us, the worlds of Science."*
> *--Ada Lovelace*

In this module we are going to learn the basics of machine learning in Hilbert spaces. The fundamental idea of using Hilbert spaces is to use the so called Kernel trick in order to construct nonlinear machines with the techniques that we have seen to construct linear ones.

The trick consists simply of changing the linear dot product by some other defined in a higher dimensional Hilbert space.

In order to understand the kernel trick we will first see a direct expression of a nonlinear machine (lesson 1) and we will see the process of interpreting this machine as a linear one in a higher dimensional space (lesson 2).

Then, we will define a dot product in this space and we will see that the machine can be expressed in terms of this dot product. Later, we will generalize the concept of kernel dot products and we will see their properties, some kernel examples (lesson 3) and fundamentals about kernel construction in order to endow learning machines with nonlinear properties (lesson 4).

The student must comnplete the four assignments in order to practice in the four above mentioned concepts.

Portrait of Ada Lovelace

English mathematician. Precursor of the Analytical Machine, a mechanical computer, and publisher of the first known algorithm for this computer.

Learning Objectives

By completing the lessons and the assignments, for this module, students will be able to:

- Explain the concept nonlinear transformation to a higher dimensional space.
- Explain the concept of kernel, and the kernel trick.
- Reproduce the definition of Mercer's kernel, the mercer Theorem and prove the Representer Theorem.
- Use the properties of kernels in kernel construction and analysis.
- Construct a nonlinear SVM for regression, classification and novelty detection using arbitrary kernels.

Required Instructional Materials

- The materials include the lessons and the assessments.
- Students must review sections 2.1, 2.2 for parts 1) to 3) and sections 3.1 to 3.13 of the book "Kernel Methods for Pattern Analysis", available online through the UNM library.
- Also, students must review the sections of papers provided in Chapter 1, in particular the sections where the kernelized versions of the SVMs are described.
- A complementary source is found in J. L. Rojo-Álvarez, M. Martínez-Ramón, J. Muñoz-Marí, G. Camps-Valls, Digital Signal Processing with Kernel Methods, Wiley, 2018. The book has free access online through UNM with your UNM email.

Activities

Besides the slides and the homework, students can enter their questions in the discussion board.

Module 6 Summary

- 5 lessons (lesson 6 optional)
- 3 assessments
- 2 Quizzes
- Weekly Discussion

If you have questions about some aspect of Learn, **UNM LEARN Support** is available to troubleshoot technical problems.

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